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Mix Master: Modeling Magnetic Reconnection in Partially Ionized Plasma

New simulations of interstellar magnetic fields open new chapter in understanding star formation.

Fort Lauderdale, Fla.—Many of the most dramatic events in the solar system—the spectacle of the Northern Lights, the explosiveness of solar flares, and the destructive impact of geomagnetic storms that can disrupt communication and electrical grids on Earth—are driven in part by a common phenomenon: fast magnetic reconnection. In this process the magnetic field lines in plasma—the gas-like state of matter consisting of free electrons and atomic nuclei, or ions—tear, come back together and release large amounts of energy (Figure 1).

Astrophysicists have long puzzled over whether this mechanism can occur in the cold, relatively dense regions of interstellar space outside the solar system where stars are born. Such regions are filled with partially ionized plasma, a mix of free charged electrons and ions and the more familiar neutral, or whole, atoms of gas. If magnetic reconnection does occur in these regions it might dissipate magnetic fields and stimulate star formation.

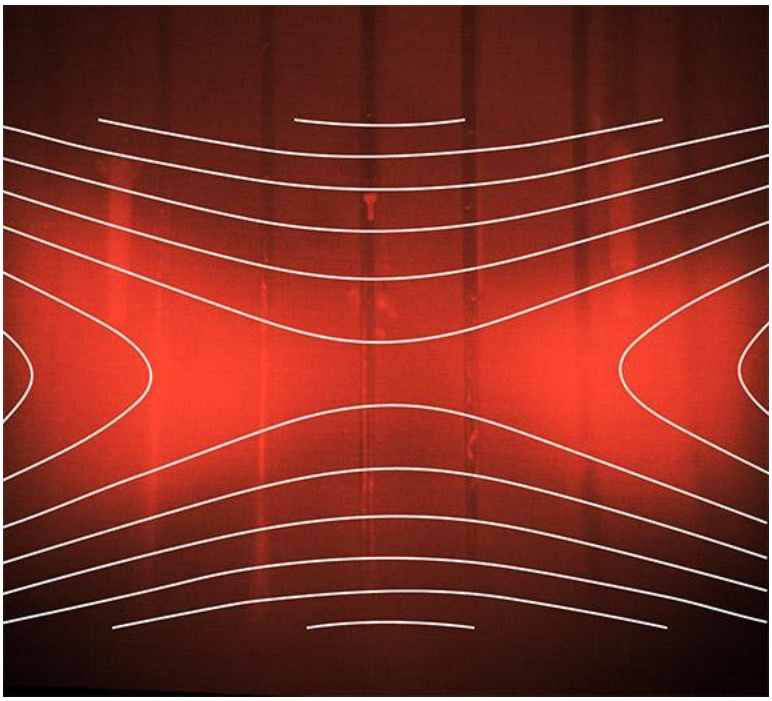

Figure 1: Fast-camera image shows plasma during magnetic reconnection with field lines rendered in white. The horizontal white lines represent the converging magnetic field lines prior to reconnection; outgoing vertical white lines represent the magnetic field lines after reconnection. Credit: Jongsoo Yoo

Researchers at the U.S. Department of Energy's Princeton Plasma Physics Laboratory (PPPL) have developed a model and simulation that show the potential for reconnection to occur in interstellar space.

"Our models show that fast reconnection can indeed occur in partially ionized systems," says Dr. Jonathan Jara-Almonte, a physicist at PPPL.

Dr. Jara-Almonte developed a mathematical model that adds the behavior of neutral particles to previous simulations of fully ionized plasma. Powerful Princeton University computers then solved the equations, which determine the motion of billions of plasma particles

These findings can help guide the understanding of how reconnection may differ between fully ionized and partially ionized plasma, and how it might affect the formation of stars. Researchers will next compare these simulations with magnetic reconnection in small-scale laboratory experiments at PPPL to validate the approximations used in the model.

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Abstract

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Session	Session CI2: Invited Basic II: Magnetic Reconnection and Shocks 2:00 PM – 5:00 PM, Monday, October 21, 2019 Room: Floridian Ballroom AB